Detecting Crystal Habits Using CERES Bi-Axial Data

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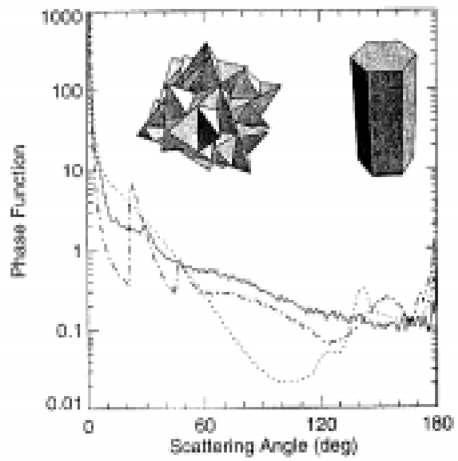
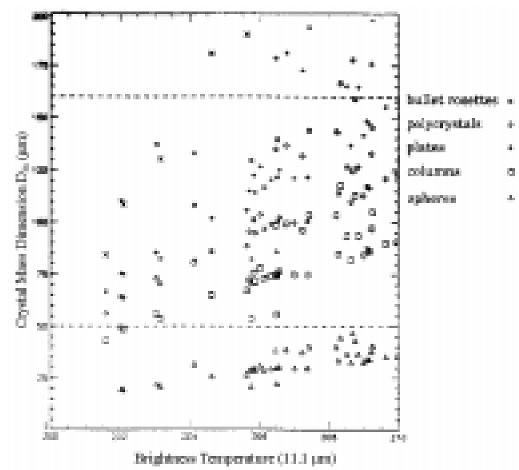
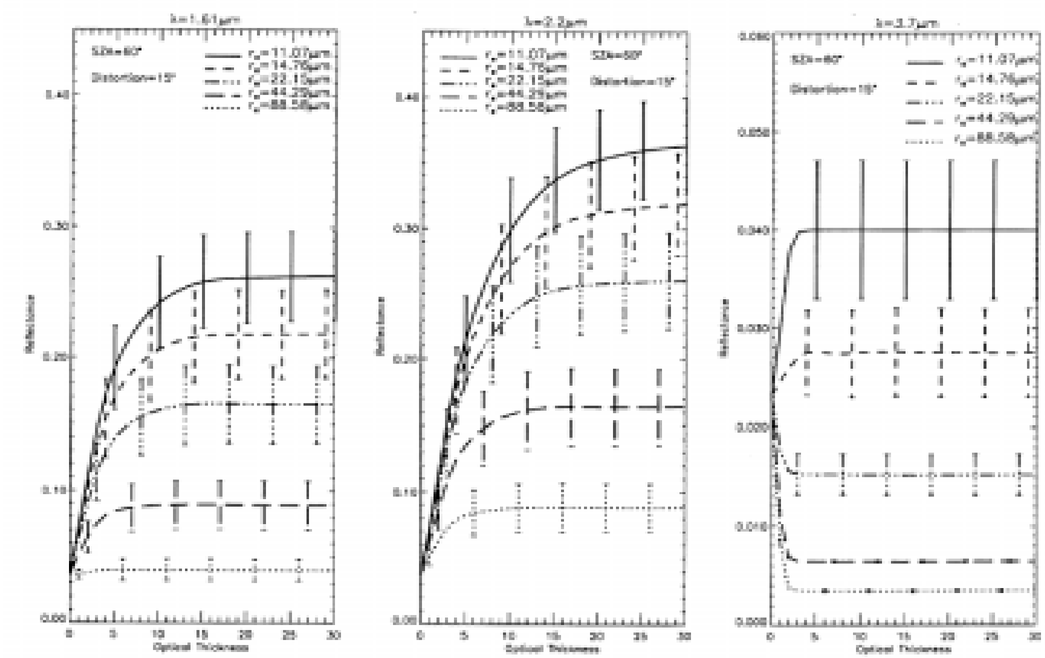
Uncertainties in Remote Sensing

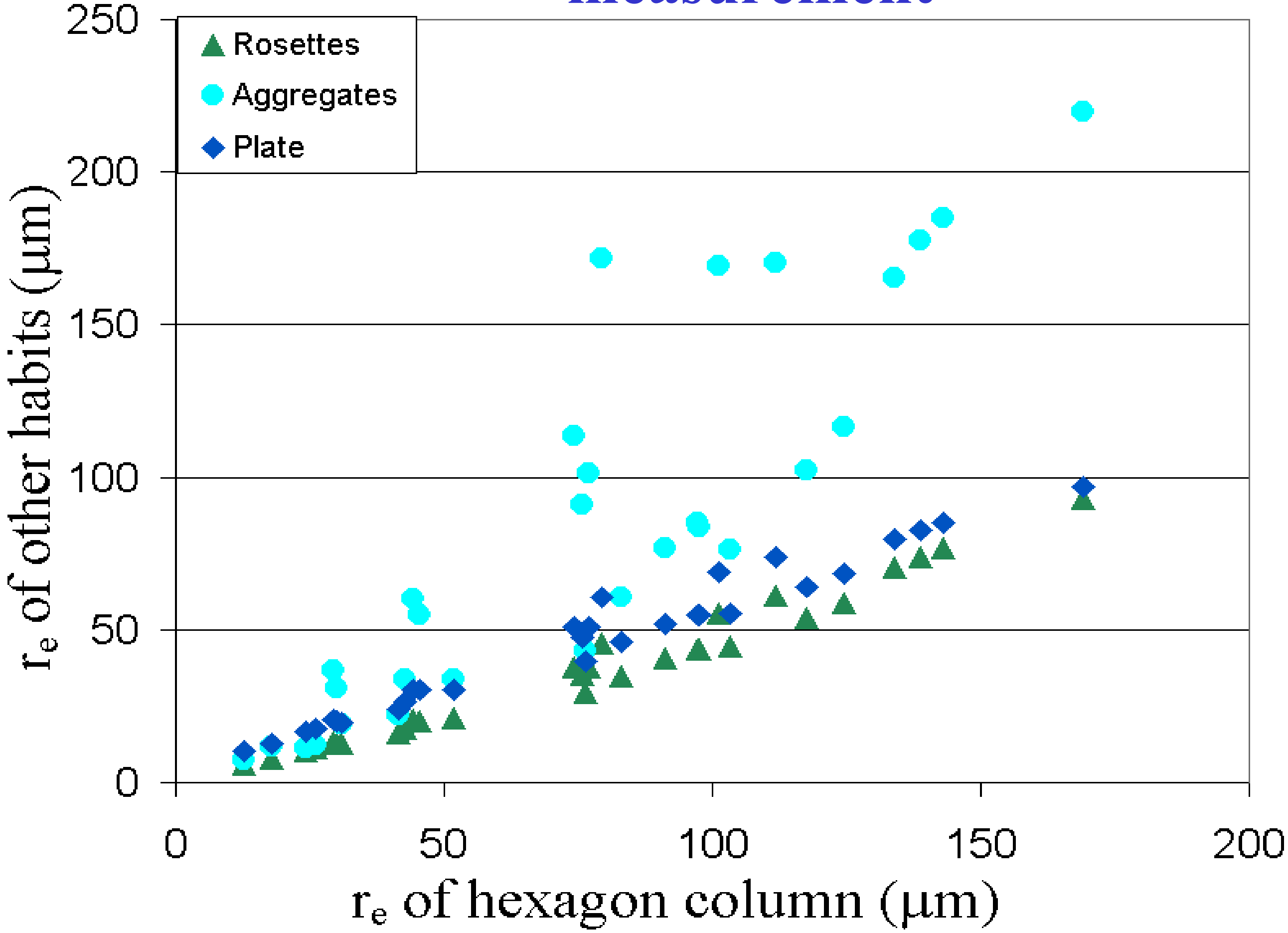






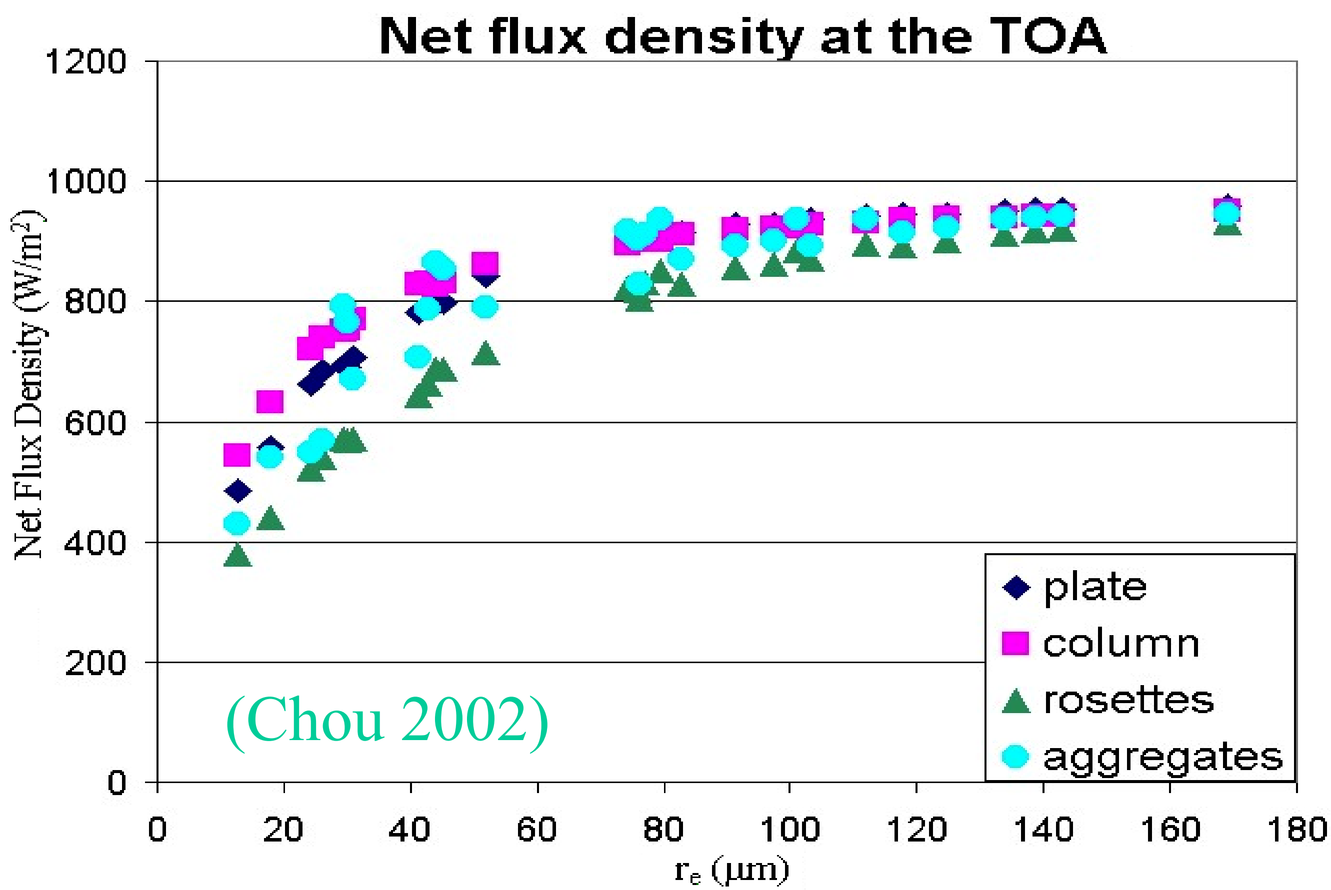
• **Retrieval uncertainties are a factor of 3~4 in optical thickness, and >10 μm in effective particle radius**

Uncertainties in Reported Effective size by in situ measurement



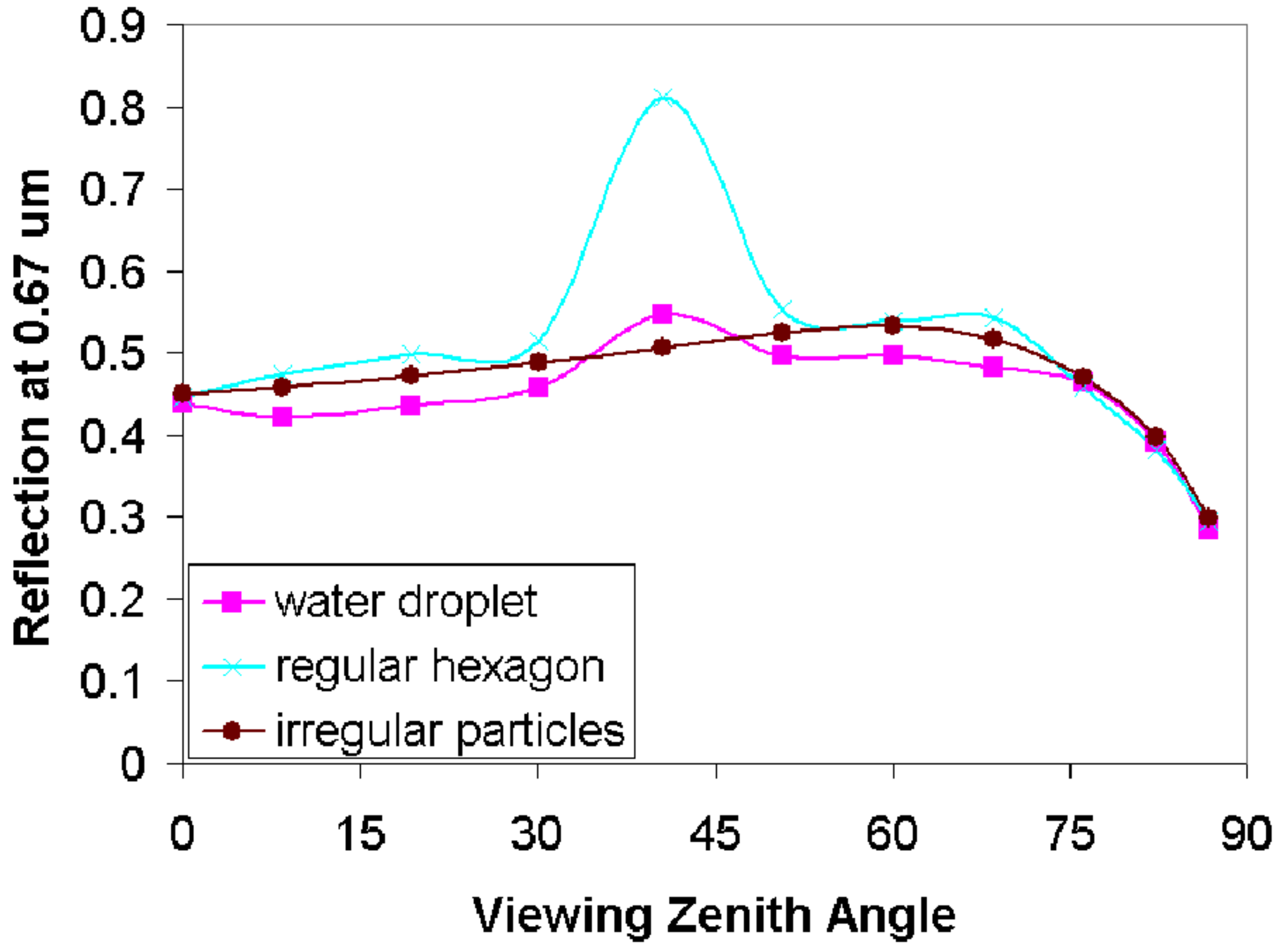
- Different assumptions of habits lead to different r_e
- Using sample cloud models leads to multiple solution in r_e

Uncertainties in Model Calculations



- The uncertainty in calculated net flux density even for a given r_e.

Discriminating shapes by enhanced backscattering

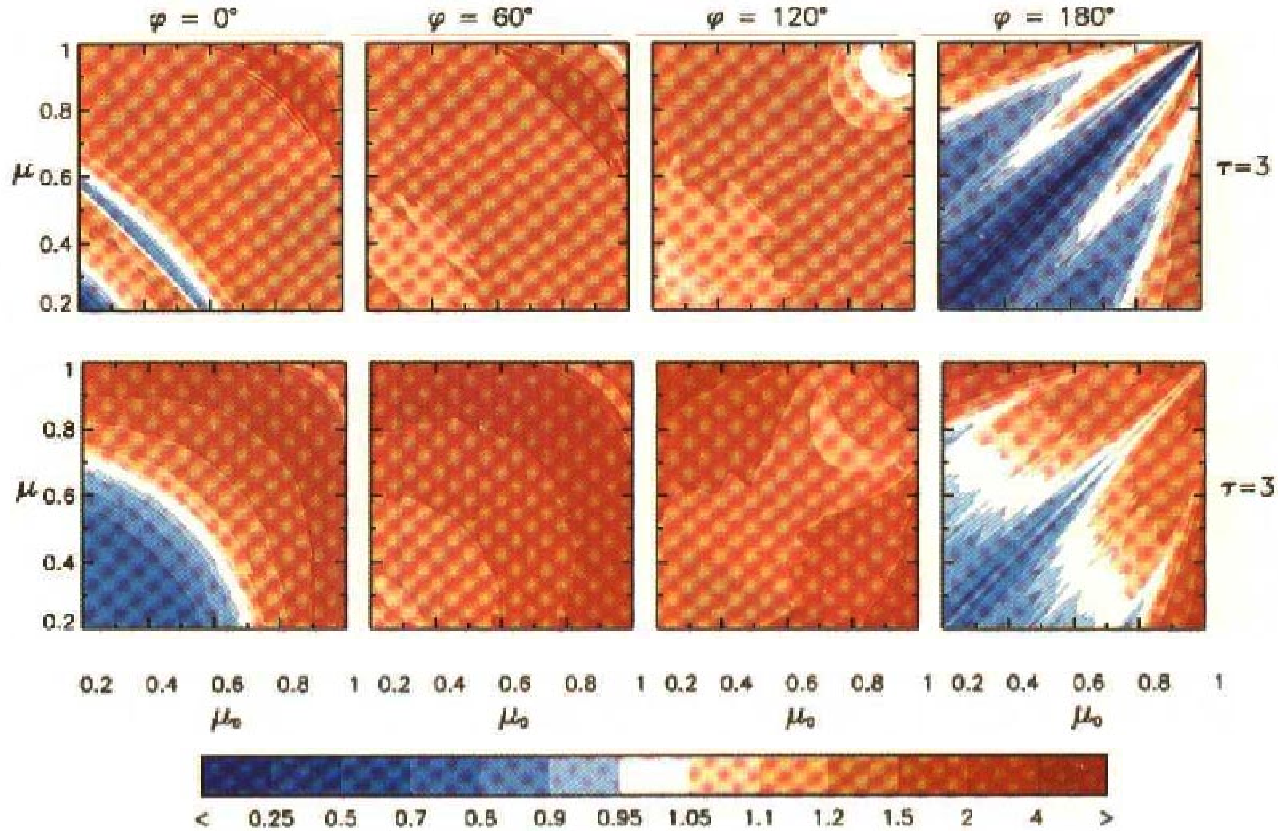


• **Behaviors of water droplet and different ice crystals (SZA=40^{o})**

Discriminating shapes by enhanced backscattering

ice cloud

water cloud



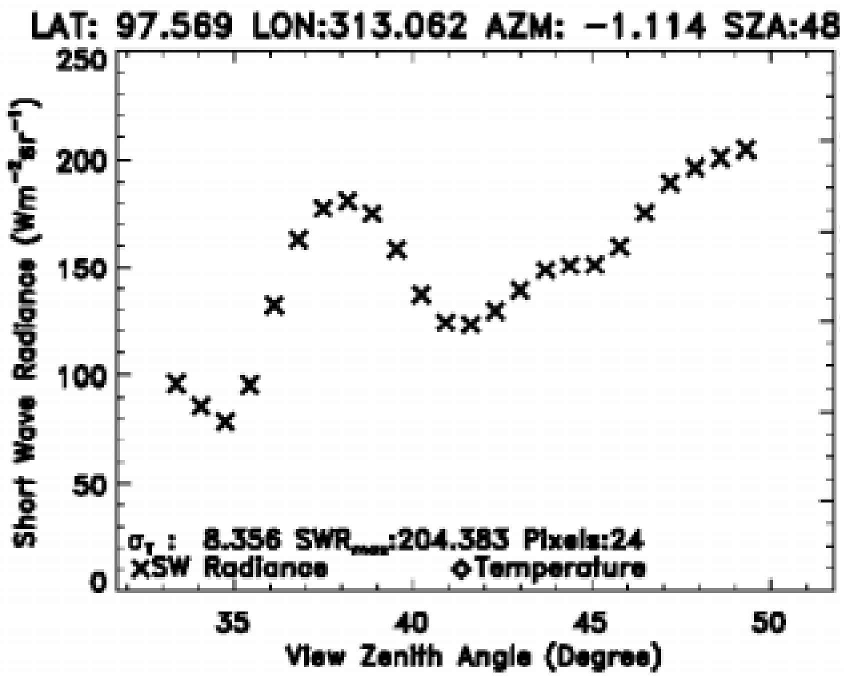
Mishchenko et al. 1996

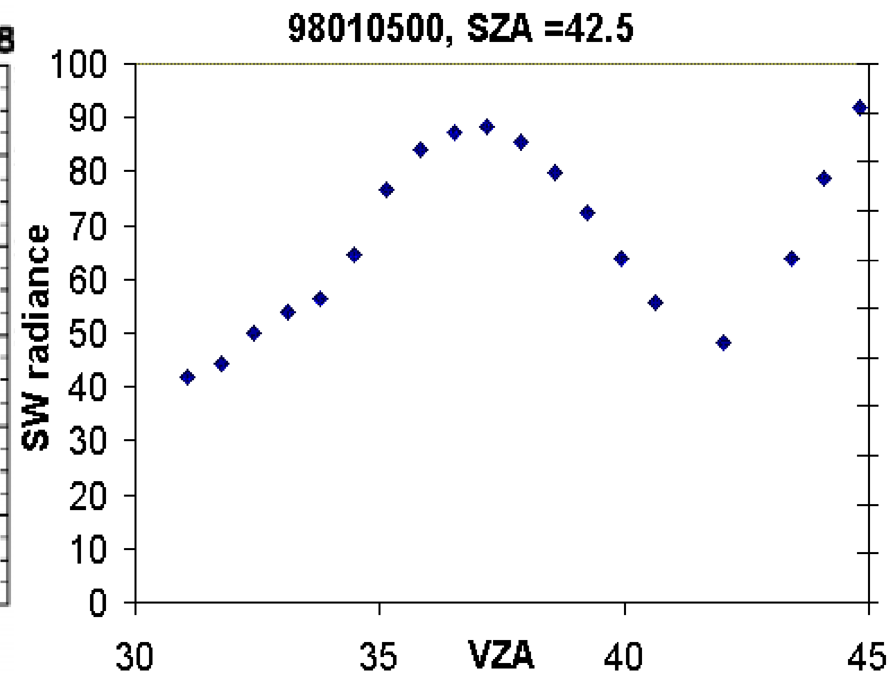
• **Similar results were obtained by others**

Data

- **Three months (9801, 9804, 9807) of TRMM CERES biaxial data: SW radiance, WN radiance, Cloud Temperature**
- **Azimuth angle close to 180^o, scattering angle within the range of 150^o 180^o**
- **Ice clouds: cloud top temperature <240 K**
- **Cloud cover 100%**
- **Water clouds: cloud top temperature > 273 K**
- **SD of Cloud top temperature as indication of cloud top morphology**

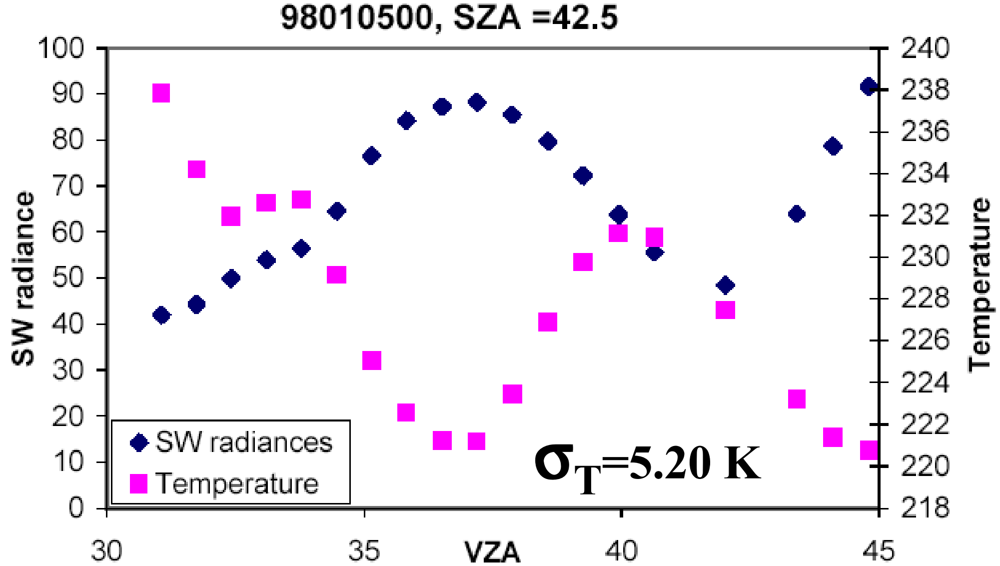
First Impression

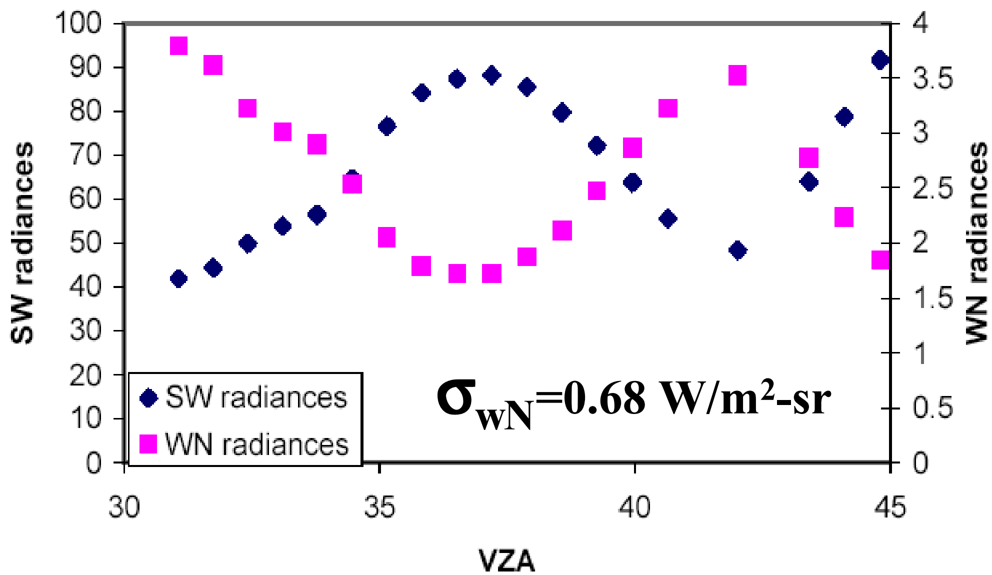




- SW radiances varies significantly and irregularly for majority of the data

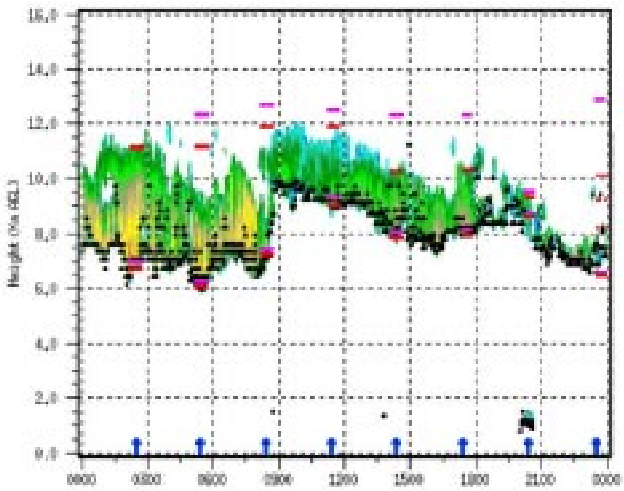
Effect of Temperature

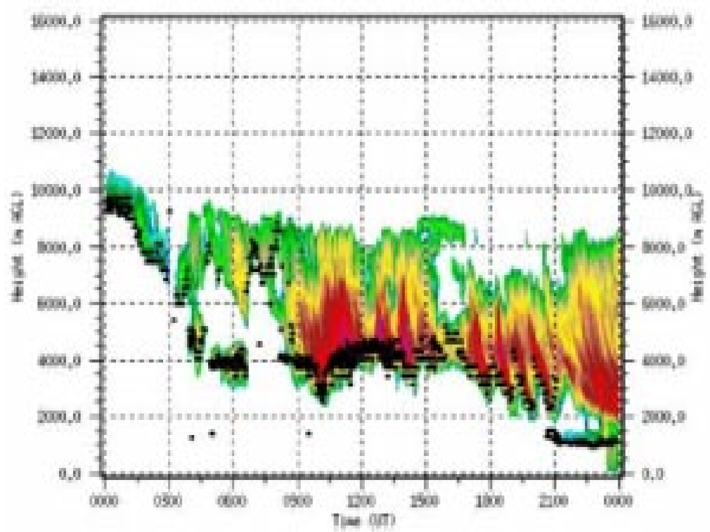


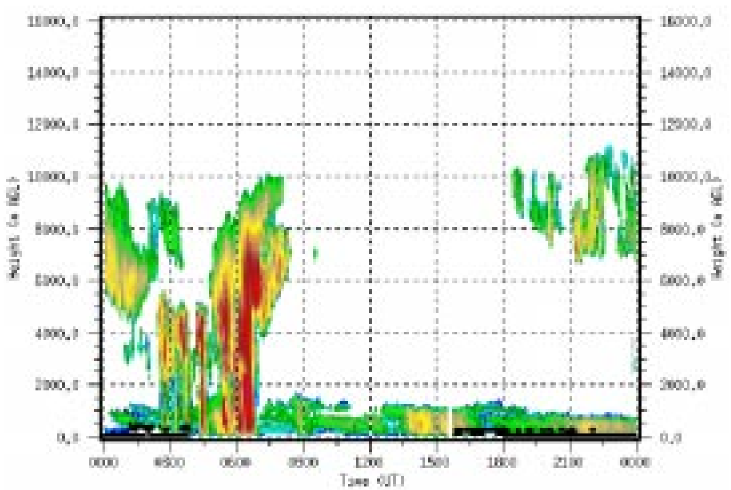


- Inhomogeneity of cloud field can significantly affect the results. Colder clouds are more reflective, which dominates the angular distribution

Cirrus Cloud Morphology

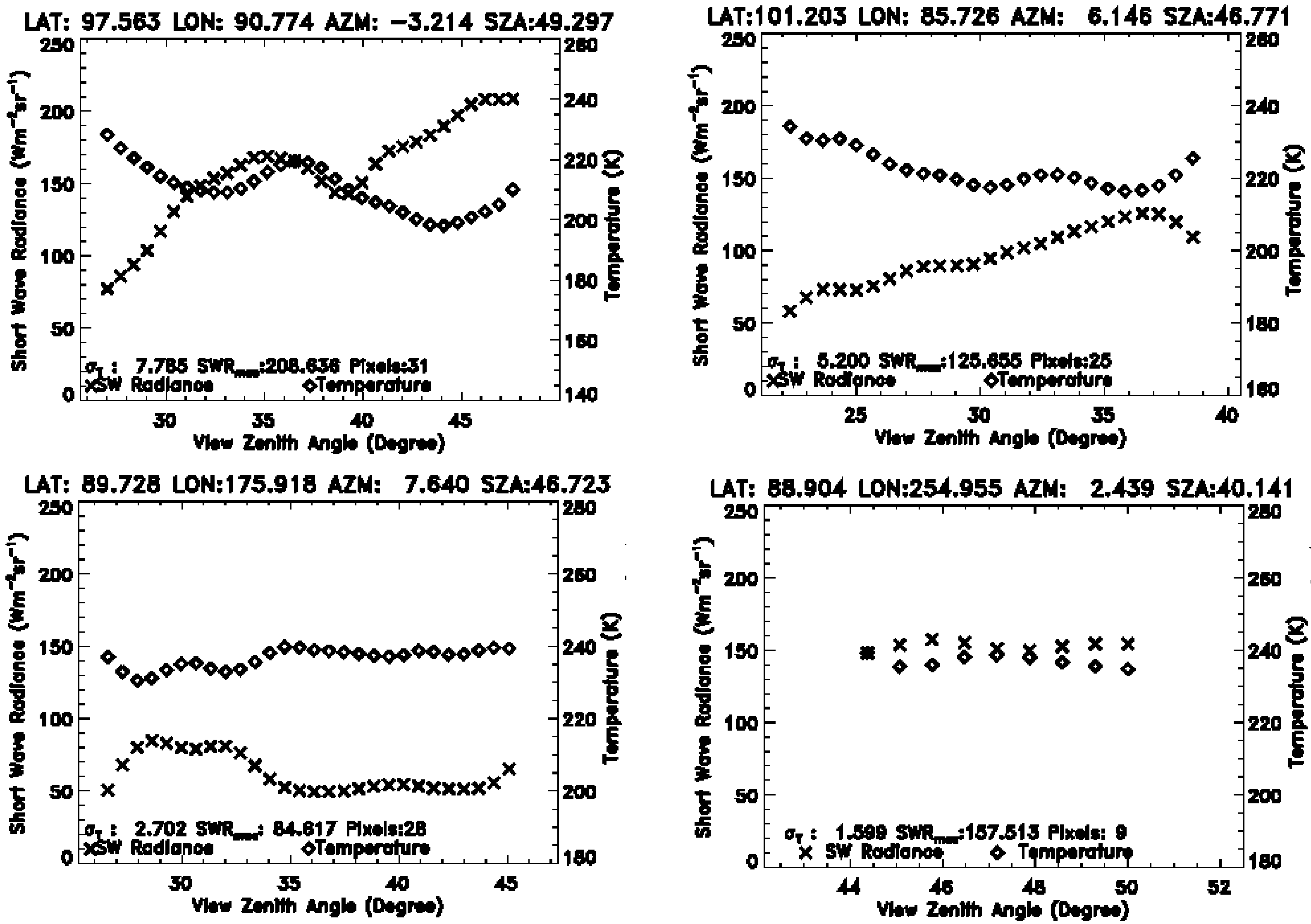






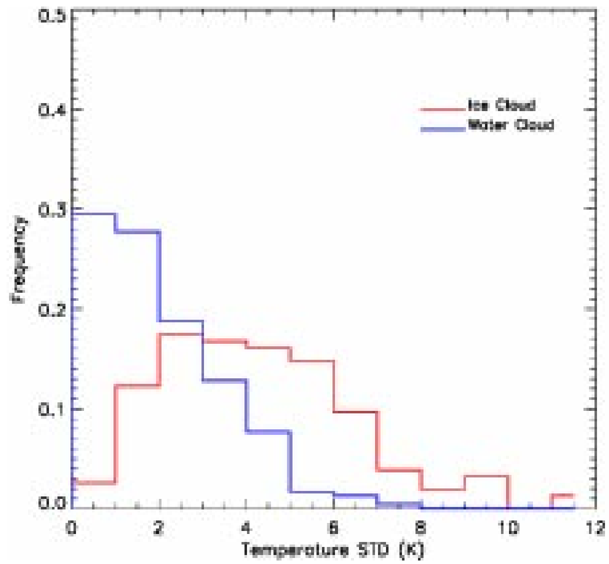
- **Cirrus cloud morphology affects the spatial distribution of reflected solar energy**

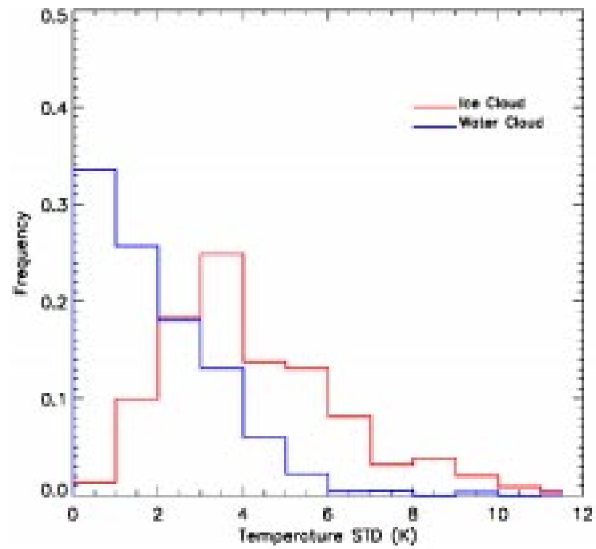
Temperature as morphology indication

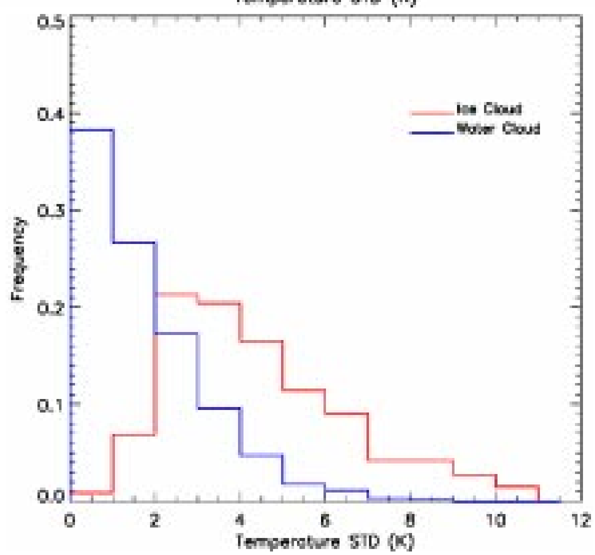


- σ_T > 2.0 K may produce sizable variations in SW reflectance

Standard Deviation of Cloud top temperature

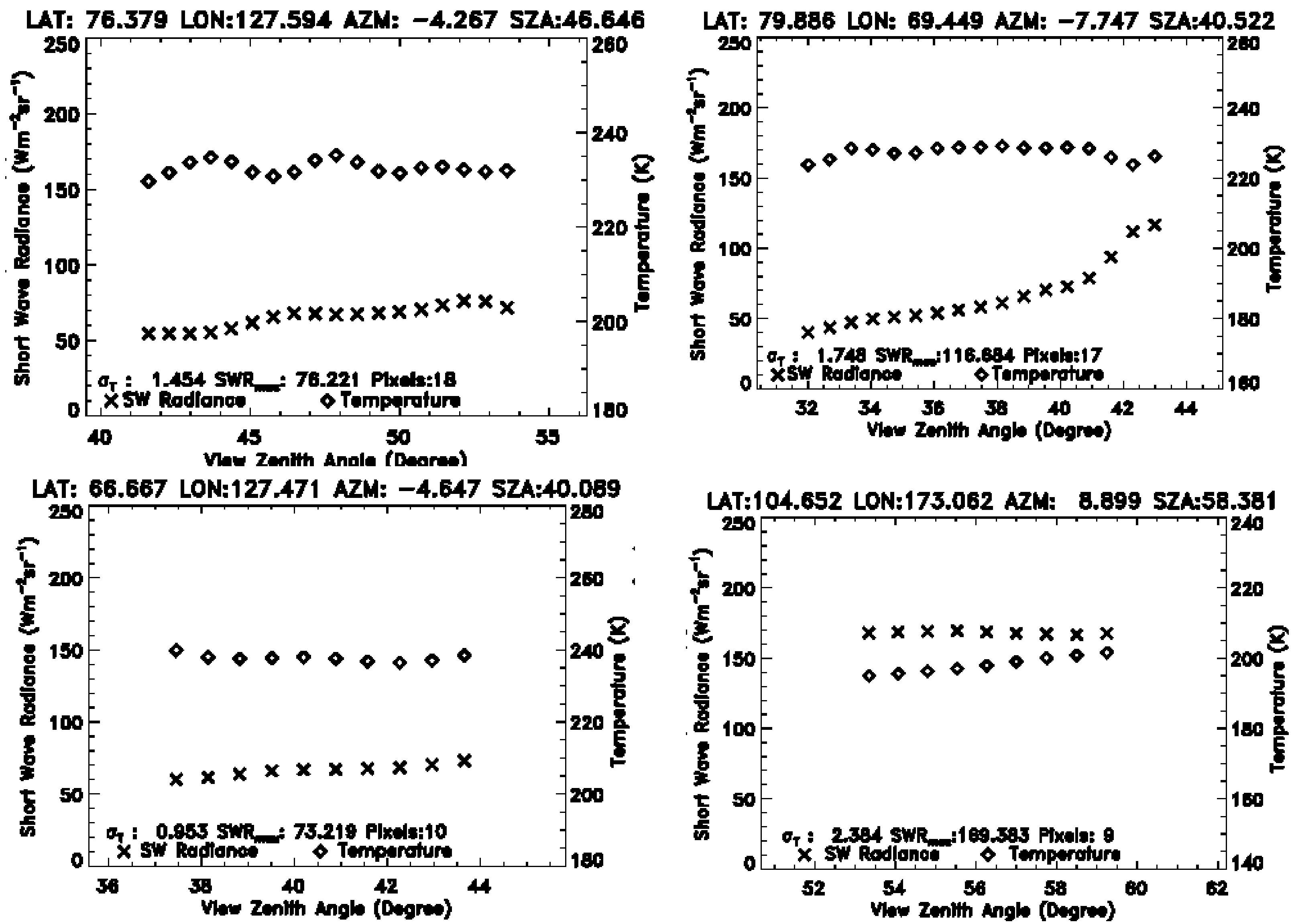




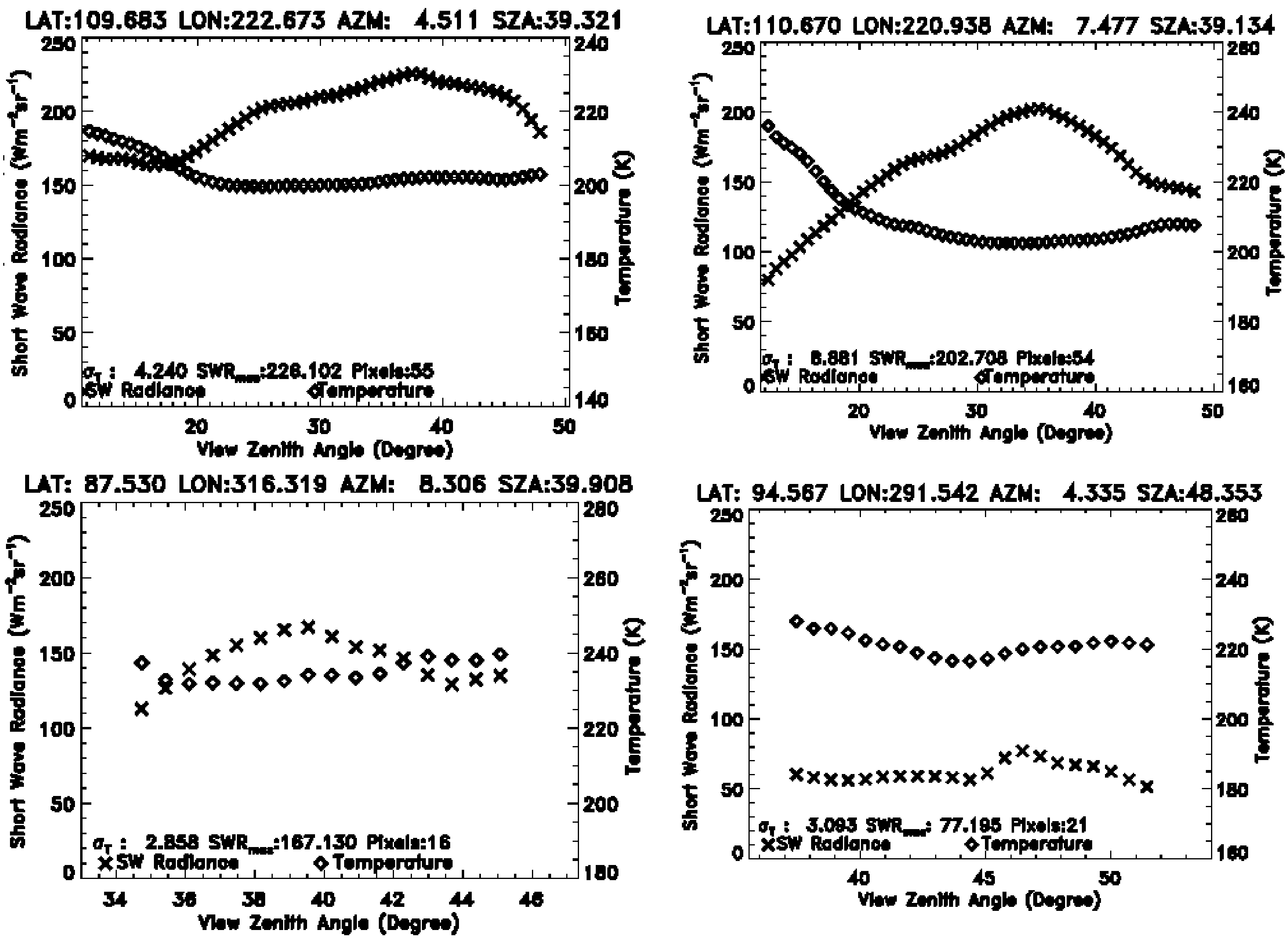


- **Majority (>90%) of cloud top temperature varies significantly.**

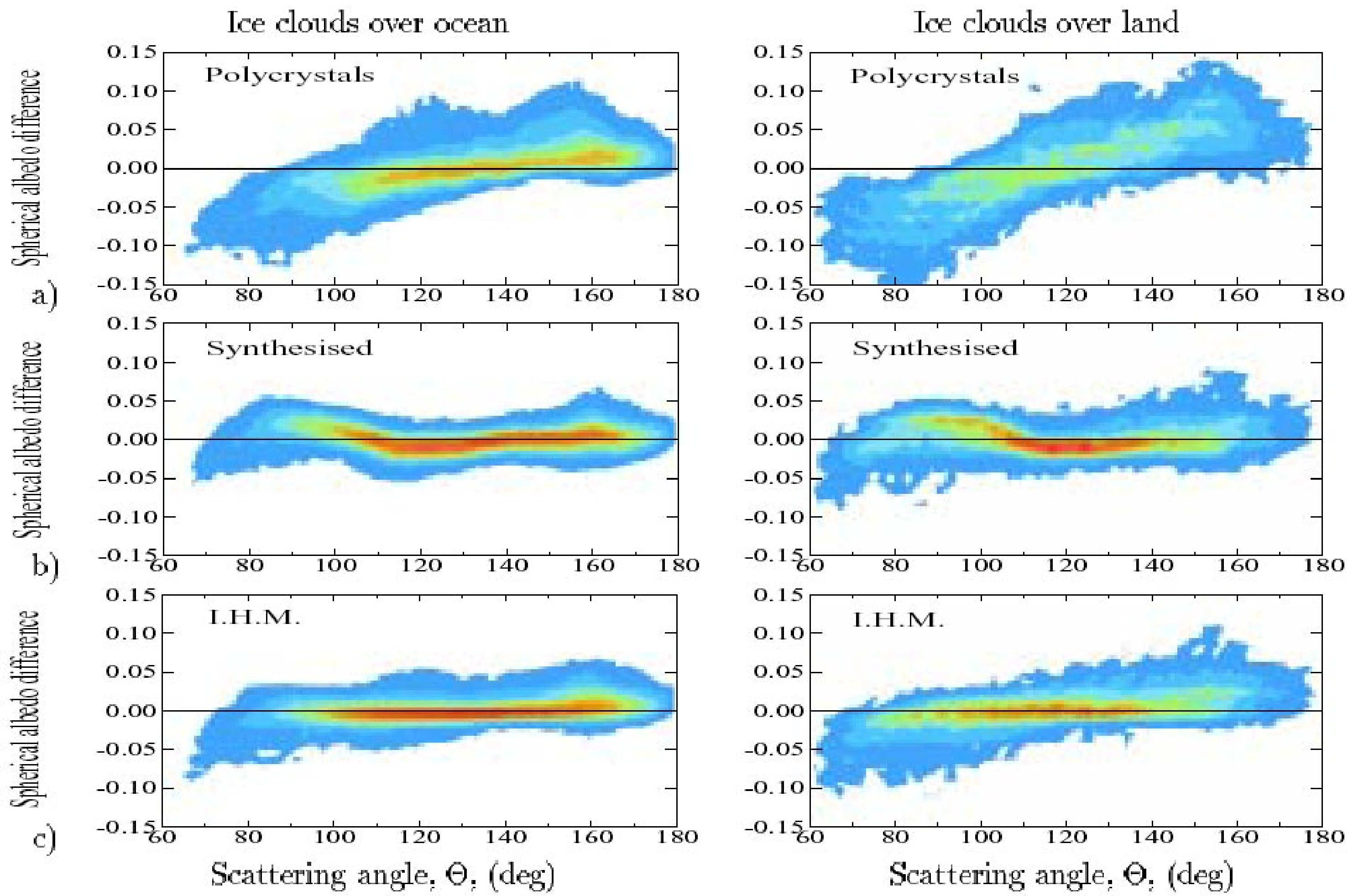
Signature of Polycrystal



Signature of Hexagon



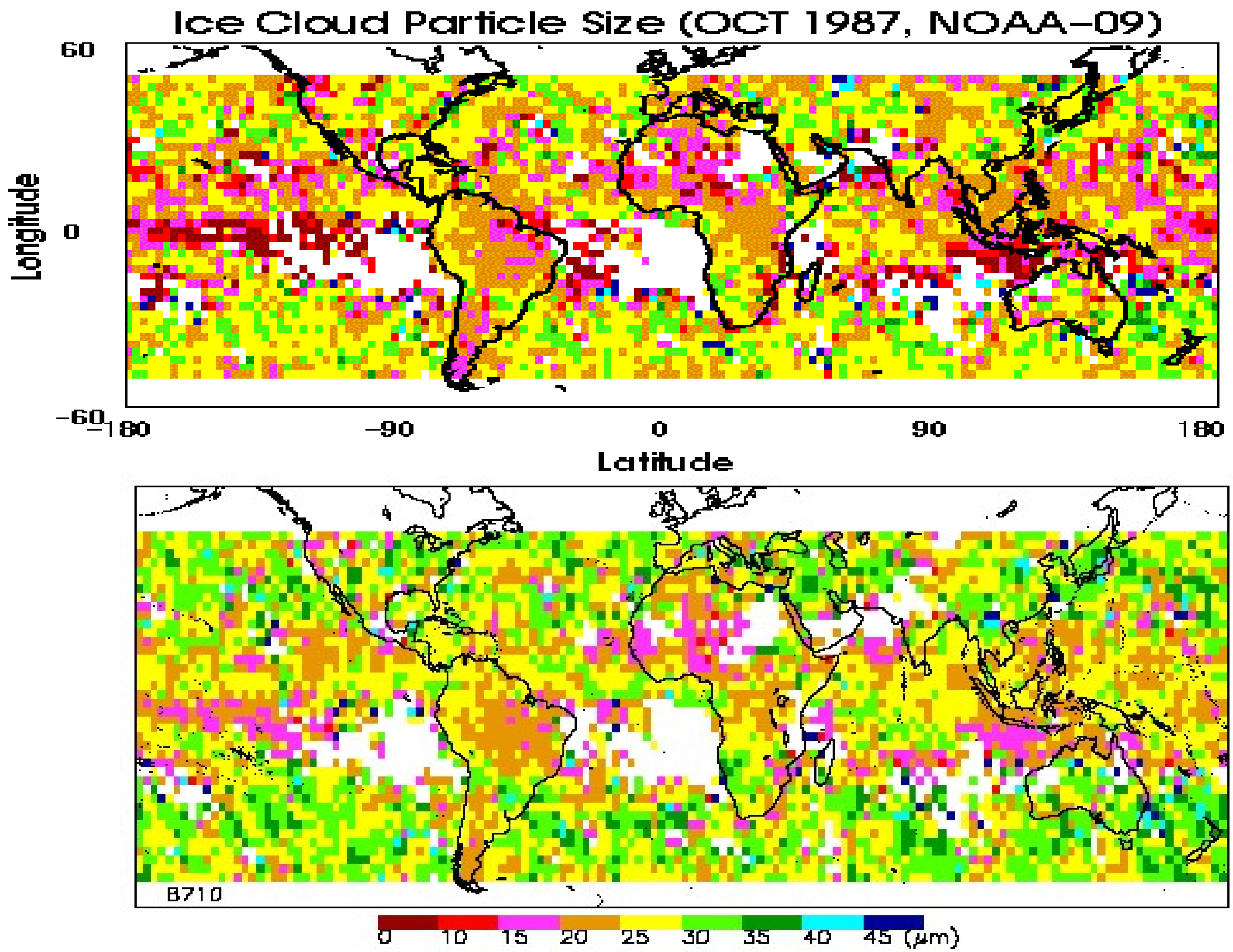
Globally averaged spatial distribution of reflected solar energy by POLDER



Doutriaux-Boucher et al. 2000

- **Pattern of Spatial distribution is mainly controlled by cloud top morphology**

Ice cloud effective radius by different phase functions

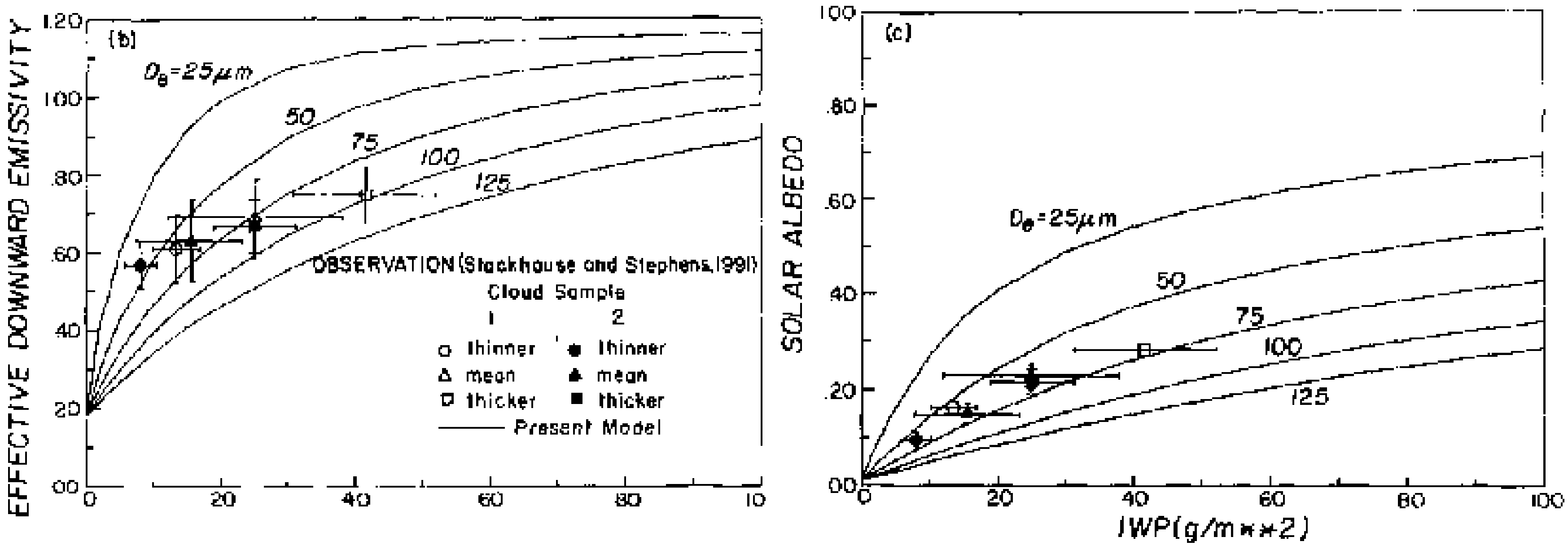


Smooth hexagons

Distorted ice crystals

• **Different phase functions lead to changes in particle size distributions**

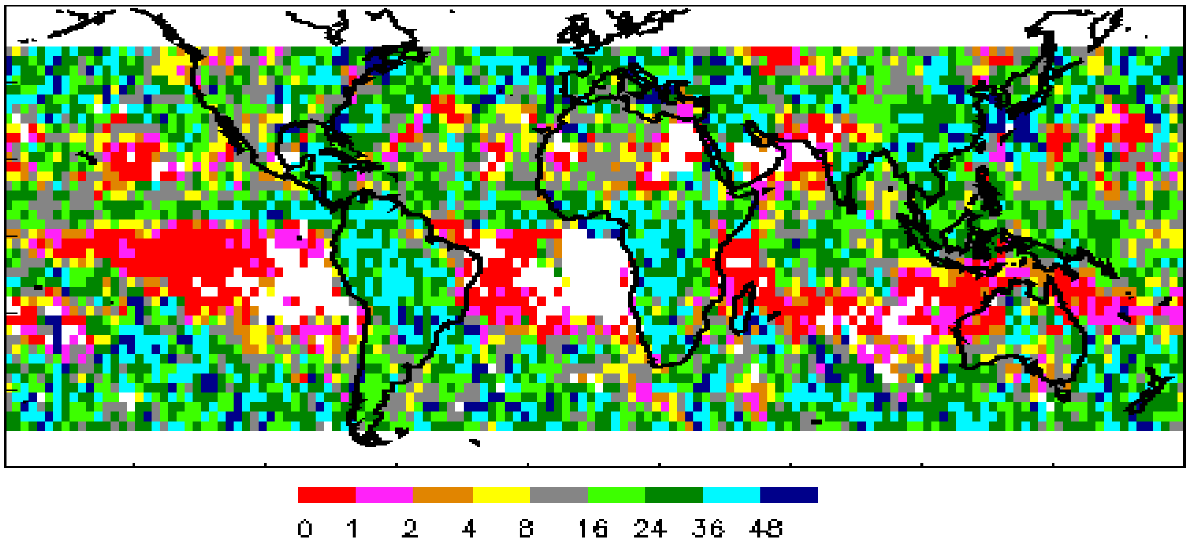
Effect of particle size on emissivity and albedo



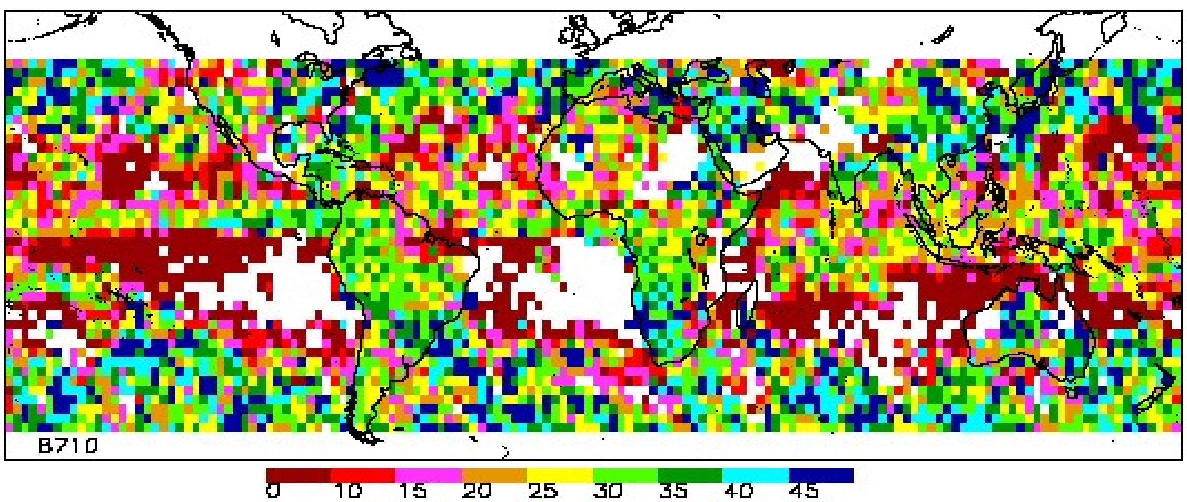
Fu and Liou 1993

- **Particle size effect is significant for both short and long wave radiation**

Ice cloud optical thickness by different phase functions



Smooth hexagons



Distorted ice crystals

- **Retrieved optical thicknesses are also different using these two phase functions**

Summary

- Three months of TRMM CERES biaxial data were analyzed to find signatures of polycrystal or regular hexagon

- Dominant factor in controlling spatial pattern of reflected solar energy is cloud top morphology (>90% of the data).

- Signatures of both polycrystals and regular hexagons were found for relatively flat cloud tops, with ~ 4 to 1 ratio in favor of polycrystals

- Averaging over large dataset, spatial pattern of reflected solar energy is featureless, closer to that of polycrystals

- Due to its significant effect on flux density calculations by particle shape, retrievals of ice cloud properties by polycrystal phase functions should be included in CERES.

The End